Course #27

Advanced Radio System Architectures

INSTRUCTOR
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TECHNOLOGY FOCUS
The ideas associated with sampling and digital signals that revolutionised modulation systems and are now revolutionising radio system design. This course continues the theme of block diagram rather than circuit diagram design, presenting an up-to-date view on concepts for advanced radio systems that incorporate digital signal processing at RF frequencies and the concepts of software defined radio. It is a practical approach for technical professionals to understand the latest designs and architectures for radio systems that include DSP.

COURSE OBJECTIVE and WHO SHOULD ATTEND
This is an intermediate to advanced level course for system architects, design engineers and managers looking for up to date information on recent advances in the field of radio system design. The objective is to expand the range of radio design into the DSP era. Learning objectives include identifying the critical RF parameters in wireless transceiver technology, understanding the various trade offs in different architectures and understanding the balance of analogue to digital processing for cost effective design solutions. These concepts have a broad range of application from low cost terminal devices for mobile communications, multifunction radio systems, remote sensing, advanced concept radios for radar/surveillance and enabling wireless connectivity in a variety of product and services.

The course is suitable for those working on embedding radio into other systems. The principles discusses are general and wide ranging for applicable in the mobile phone industry, satellite communications, defense, such as radar and EW / ECM as well as adding wireless features to sensors and IoT type devices.

COURSE CONTENTS
This course builds on the Radio System Design -Theory and Practice course, but does not require that course as a prerequisite. The key basics are part of the introduction, which then builds and expands the necessary theory, principles and practical design information for radio transceiver design for standards such as CDMA / W-CDMA, WLAN, broadcast standards such as digital TV and other OFDM systems. Tools such as spreadsheets and system design examples using Applied Wave Research VSS software are used to illustrate topics though out the course.

The course is illustrated with some custom applications, various spreadsheets, simulations and other useful information from application notes. Copies of all the Excel examples, many useful application note and other material is provided to each student on a CD. This is made more accessible via an innovative wiki based hypertext structure that allows easy access using a standard web browser.

Day 1 Introduction, NF and IM refresher, and Sampling
Sampling of analogue signals is well established in the baseband, but with advances in analogue to digital converters (ADCs) and digital signal processing, it is now possible to apply these techniques directly to signals at RF frequencies. The important features of ADC and DAC are described with reference to sampling theory, baseband filtering, noise figure (NF), intermodulation (IM) and Eb/No. Also examples of digital processing such as digital down conversion and filtering are covered with a view towards application to software-defined radio. The focus is on system level parameters such as signal and noise levels and dynamic range. Standard cascade analysis is extended to incorporate the ADC function.

Day 2 Frequency Conversion and Frequency Synthesis
Mixing and sampling are related processes, this section builds on the essentials from the first day; introducing analogue mixers. In particular, key features such as image band, choice of IF and spurious signals are discussed along with the important concept of IQmixing for modulation and demodulation. Examples are used to illustrate various points and to highlight the parallels and differences with sampling.

All systems using frequency conversion, whether via an analogue mixer or using sampling, require a local oscillator (LO) or clock. Options and designs for frequency synthesisers are described including details of oscillators, stability, tuning range and phase noise. Examples of direct, indirect and digital synthesisers are described. System level performance is emphasised, with mixers, multipliers and phase locked loops (PLL) analysed in terms of spurious signal and noise generation. Measurement techniques for gain and phase margin in PLLs as well as phase noise are described. With the importance of IQ techniques, the methods for creating accurate IQ signals are described with examples of modulators and demodulator systems.

Day 3 Frequency Planning, Transceiver Architectures and the role of DSP
Bringing all the concepts of the previous days together, this section summarises analogue and digital filter essentials, then examines real system architectures. Using well-chosen examples, the strengths and weaknesses of different systems are examined. Essential principles of the superhet radio are described with different approaches such as single/multiple IF designs as well as direct conversion (zero) and near zeros IF options. Different frequency and gain planning and distribution options are highlighted, including the incorporation of automatic gain and frequency control loops. Finally, trends in DSP, software defined radio and the relevance to radio system architecture are described with special emphasis on the partition of analogue to digital functional blocks and the balance of hardware to software. Understanding these different ways of achieving the essential functions of a system will mould the architectural concepts in the future.

Throughout the lectures, various practical tools including spreadsheets are used to illustrate key issues and to provide information for future analysis and design.

A copy of all the Excel examples, many useful application notes, and alphabetic list of abbreviations and other material is provided to each student on a memory stick This is made more accessible via an innovative wiki based hypertext structure that allows easy access using a standard web browser.